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COMMAND AND CONTROL OF THE AMERICAN FIRE SUPPORT SYSTEM 1/1

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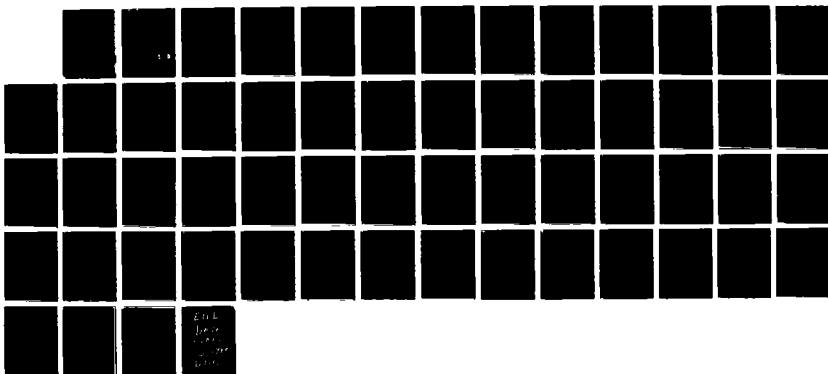
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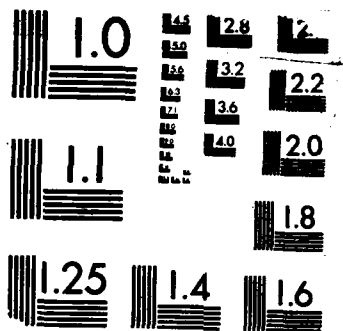
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Command and Control of the American Fire Support System

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ABSTRACT

Command and Control of the American Fire Support System, by Major Bruce A. Brant, USA, 52 pages.

▶ The purpose of this study is to determine the most appropriate command and control system for the U.S. Army fire support system. Specifically, it addresses the question of how tactical fire direction should be controlled in the direct support field artillery battalion. The major problem concerning today's field artillery is the coordination of indirect assets with the commander's scheme of maneuver and direct fire systems. To examine the coordination problem, this study compares the tactical command and control systems of the Soviet Union, Great Britain, the present U.S. TACFIRE system and the future American system, the Advanced Field Artillery Tactical Data System (AFATDS).

The study makes three main conclusions. First, future planned automation provides a means of greatly enhancing the capabilities of fire support assets. Second, the fire support system is improved if the fire support officer controls fires instead of the fire direction officer. Finally, there needs to be a philosophical change within the U.S. fire support community. The final conclusion refers to the practice of placing the most experienced personnel near the guns rather than with the maneuver units which is the practice of both the Soviets and British.



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Introduction

There are three distinct but inseparable elements in the fire support system. These are:

- Target acquisition - the eyes and ears of the system.

- Weapons and ammunition - the muscle of the system.

- Command and control - the brain of the system that coordinates and directs the tactical and technical actions needed to place fires on a target.

The goal of the fire support system is to integrate these three elements in order to achieve the best results from available assets. By doing this effectively, the full potential of each system is used and the combat power of all systems together is increased.¹

Technological advances in lethality, speed, mobility, and communications have increased the need to coordinate all systems on the battlefield for maximum effectiveness. This synchronization is the arrangement of systems on the battlefield in time, space, and purpose to bring maximum combat strength to the decisive point and or time. It concentrates the forces, fires, and other support assets at the point of decision. Fire support is a major part of this battlefield synchronization.

The purpose of this study is to determine the most appropriate command and control system for the U.S. Army fire support system. Specifically, it will examine the question of how tactical fire direction should be controlled in the direct support field artillery battalion.

The battlefield environment is dynamic. The command and control of the fire support system must survive on the modern

battlefield, support the destruction of enemy forces, be flexible enough to change with the U.S. force structure, and have the potential to accommodate future artillery developments.

Today's battlefield and that of the near future is far different from those of the past. It extends over a wider area. Deep reconnaissance, air mobility, long-range fires, special operating forces, and Soviet doctrine ensure that nonlinear operations will be the norm. Logistical support will be austere. Offensive actions will require isolation of the battle area in depth as well as defeating an echeloned force. Key to successful defense will be the ability to detect the attack early, synchronize assets, interdict echeloned forces, and defeat large formations by fire and maneuver. Because of the nonlinear battlefield, offensive and defensive actions will take place simultaneously. The longer range and increased lethality of modern weapons systems will result in rapid destruction of vulnerable targets at the cost of high ammunition consumption rates. Developments in wide ranging surveillance, target acquisition sensors and radars, and communications equipment, broadens the width and extends the depth of the modern battlefield. Today's battlefield includes chemical warfare and, in a high-intensity war, probably will include a nuclear and biological environment. Terrorists, guerrillas, and saboteurs to search out and destroy critical targets in rear areas will be commonplace. These are just a few features that will make up the modern battlefield. The fire support system must be able to survive and be effective in this environment.²

The greatest potential threat against command and control

systems is the Warsaw Pact force's capability to employ their large quantities of electronic combat weapons to conduct an aggressive campaign against friendly command, control, and communications systems. The automated fire support command and control system for conventional, nuclear, and chemical fires is likely to be a primary target for either physical destruction or electronic warfare disruption.³

A fire support system must be flexible enough to support the changing force structure. Recent modernization of major weapons systems such as the M-1 tank and M-2 infantry fighting vehicle (IFV) created major reorganizational and doctrinal changes in the U.S. Army. The advent of light infantry divisions, with their mission of rapid deployment, coupled with the need to support six other type divisions provides a massive challenge for a fire support system. It must be adaptable to any changes in structure or future doctrine.

The field artillery itself is also placing requirements on the fire support system as a result of the modernization process. One of these artillery trends is the Howitzer Improvement Program (HIP) which makes each M109 howitzer an autonomous firing unit positioned away from a battery area. It will have a self-locating ability as well as onboard directional orientation and continuous communications with the battery computer. The Multiple Launcher Rocket System (MLRS) already has these capabilities plus its own onboard computer. Other advances for the near future include longer range weapons resulting from new composite materials in tubes, liquid propellant, and magnetic propulsion. Robotic fire systems are also being developed.

These additions to the field artillery increase the effectiveness of fires only if they are controlled by an adaptable system.

The major problem of the field artillery is no longer the solution of the technical gunnery problem; it is the coordination of indirect assets with the commander's scheme of maneuver and direct fire systems. To examine the coordination problem, this study compares the tactical command and control systems of the Soviet Union, Great Britain, the present U.S. TACFIRE system and the future American system, the Advanced Field Artillery Tactical Data System (AFATDS).

There were several reasons for selecting these systems. First, the present TACFIRE system serves as a familiar basis of comparison. Second, the Soviets are the greatest threat, have the most artillery, and have a system that is used by most of the Warsaw Pact countries. Third, the British system is used by several NATO countries. Finally, AFATDS is the proposed U.S. system of the future.

The basis used to compare the systems are the areas listed in FM 6-20 Fire Support in Combined Arms Operations: the essential characteristics of fire support. The first is the ability to mass fires. Second is the responsiveness to reduce enemy attack momentum, attack fleeting targets, diminish formations before they attack or disperse, and react to short decision-making time. Next is survivability on a battlefield. Mobility is another critical fire support characteristic as the system must be able to stay with the supported force. The final characteristic is flexibility. The system has to accommodate the rapid changes on the battlefield.

The assumptions used in this study are:

- The U.S. will remain behind the Soviets in the number of artillery weapons fielded.
- The U.S. will continue the policy of employing fewer "smart" munitions rather than massive amounts of "dumb" rounds.
- The U.S. Army will adopt AFATDS.
- TACFIRE will be used until 1990-1995 by at least the National Guard and Reserve forces.
- Great Britain will field the Battlefield Artillery Target Engagement System (BATES).

Because of several constraints and restrictions imposed on this study, the following limitations are made:

- It is unclassified.
- Only four tactical fire control systems are analyzed.
- AFATDS software is not finalized and the hardware may change somewhat before fielding. This paper assesses what is currently projected.
- Missile units are not discussed.
- The U.S. manual tactical fire direction system and the lightweight TACFIRE system are not part of the study.

U.S. Army Fire Support System

Organization

The Army corps is the highest organizational level of U.S. field artillery. The number and type of field artillery units assigned to a corps vary depending on the mission and the number and type of divisions assigned to the corps. The corps artillery headquarters provides tactical control of its units. The corps commander gives divisions additional field artillery support by

employing corps units in support of the divisions and other corps maneuver elements such as the armored cavalry regiments. He provides additional field artillery support throughout his area of responsibility using two methods of tactical control. First, he can attach field artillery brigades, battalions, and batteries to divisions. Second, he can assign field artillery units tactical missions that make them more responsive to the fire support needs of specific corps maneuver elements.

Each corps may be allocated one or more field artillery brigades. The brigade can control up to six battalions and is organized dependent upon its mission and area of responsibility. It may include Lance missile battalions, Multiple Launcher Rocket System (MLRS) battalions or separate batteries, and a mixture of cannon units. The ability to organize brigades with different mixes gives the commander flexibility in focusing his combat power. Brigades are either attached to a division, given a tactical mission to support a division or retained by the corps commander for specific missions.*

The next level of organization is the division artillery. Organization and equipment varies with the type of division. Normally, the division artillery (DIVARTY) has three battalions that usually have direct support missions to maneuver brigades, an additional cannon battalion or MLRS battery that is usually in general support of the division, a target acquisition battery and a headquarters battery.

The final level of organization is the battalion. It is usually composed of three firing batteries of six or eight guns each, a headquarters battery, and a service battery. There are

also separate batteries, such as MLRS in Division Artilleries and separate organic batteries in some armored cavalry regiments. Each battalion is given a tactical mission by its higher headquarters.

Tactical Fire Direction

Studies following World War II determined that future battles would be characterized by a profusion of moving targets that required attack under critical time constraints. Priorities for fire support systems needed to be better established but remain flexible. It was further decided that manual methods for direction, control, and coordination of fire support were inadequate for modern battlefield conditions. Automatic data processing (ADP) systems would be needed in the future; accordingly, this led to the fielding of the Tactical Fire Direction System (TACFIRE) in the late 1970's. It is the fire support command and control system used by most active duty field artillery battalions today with the exception of the light divisions where its size and bulk make it impractical. The motorized division uses an updated and lighter version of TACFIRE.²

TACFIRE consists of two types of central computers and three types of remote terminals. The computers perform tactical and technical fire direction and the remote terminals are used to communicate with the computers.

The remote terminals are issued to the elements of the fire support and command and control systems which require access to computers. The company Fire Support Officer (FSO) uses a digital message device (DMD) to communicate with the battalion computer.

Other remote terminal users (Fire Support Elements, FSOs, and the field artillery battalion S-3) have a Variable Format Message Entry Device (VFMED) to transmit and receive digital messages from the computer.*

The firing batteries now use the Battery Computer System (BCS), which interfaces directly with TACFIRE, to solve the technical gunnery problem and transmit fire commands to the Gun Display Unit (GDU) at each howitzer. Technical firing data may also come to the battery Fire Direction Center (FDC) directly from the battalion TACFIRE computer.

In the American fire support system, the ultimate responsibility for the integration of all fires is the maneuver commander's.⁷ His principal assistant for the integration and application of all fire support to enhance the scheme of maneuver is the field artillery Fire Support Coordinator (FSCCOORD). The title of FSCCOORD usually refers to the highest level field artillery commander associated with the maneuver commander. Therefore, the corps artillery commander is the FSCCOORD for the corps, the DIVARTY commander is the division FSCCOORD and the direct support artillery commander is the maneuver brigade FSCCOORD. The FSCCOORDs have staffs that do the routine fire support coordination in their absence. The corps and division FSCCOORDS have Fire Support Elements (FSEs) that work in the maneuver unit headquarters. The maneuver brigade and battalion commanders have fire support officers (FSOs) provided by their supporting artillery unit to coordinate their indirect fires.

The direct support battalion is authorized a major as the FSO of the maneuver brigade. The brigade FSO is authorized three

captains that work as battalion FSOs at the maneuver battalions in the brigade. In general terms, the FSO's job is to advise the maneuver commander on the best way to enhance his scheme of maneuver with indirect fires, to coordinate all the assets, and to control the fires for the maneuver unit.

The maneuver company has a company FSO, a lieutenant, who, in addition to coordinating fires for the company, can act as an observer. Working for the company FSO are several NCO observers. The size of the Fire Support Team (FIST) depends on the type of company.■

The artillery lieutenant has the responsibility of preparing the company indirect fire plan, coordinating the use of the company and battalion mortars as well as his own direct support battalion, naval gunfire, and air assets. When the plan is executed, he must control all fire support means as well as command and supervise his assigned observers. As mentioned above, he may request and adjust fire himself.

The direct support battalion FDC plays a major role in the command and control of tactical fire direction. The battalion FDC operates and maintains the battalion computer. It computes the tactical and technical fire control solutions and directs and controls the fires of organic and supporting field artillery units.▼ When a fire plan is received from the FSOs, the FDO reviews it to assess technical fire control problems. After resolving all discrepancies, the FDO passes the fire commands to the firing units.

During a normal fire mission, the FDC receives a request for fire from an observer or FSO. The computer displays warnings of

violations of fire control solutions for each mission. After reviewing the fire control solution, the FDO either recomputes, deletes, or transmits the fire commands.¹⁰ The FDO is the link in the system who makes the final decision in fire direction.

Characteristics of Fire Support

The Ability to Mass Fires

TACFIRE is an excellent tool to assist in the massing of field artillery fires. It considers all reinforcing units or other units that support the direct support battalion. The computer selects up to 15 units to engage a target. The program formulates the fire order from the commander's criteria and the joint munitions effects manual (JMEM) data.¹¹

Responsiveness

Theoretically, TACFIRE should be very responsive to changing situations. In reality, this is not the case for several reasons. First, voice command fire (CF) nets are overcrowded with users that do not have DMDs or cannot enter the digital net. Up to 15 users can request fire over the single CF net, which causes overcrowding, especially during periods when TACFIRE is inoperative. The strongest radio gets the request, which can delay more important missions. Second, requests for fire tend to back up during engagements and it is difficult to override the priority queuing sequence, in part because the Task Force FSO, when away from the Tactical Operations Center (TOC), cannot monitor the fire nets.¹² Third and most important, the individual deciding whether or not to grant the fire request is the FDO who may not have the latest information on the current situation. The FSOs are more involved in the engagement and are

more aware of the changing priorities of the battle; yet they are requesting fire instead of commanding fire.¹³

Survivability

Overall, the TACFIRE system is not very survivable. It emits a distinctive electronic signature that is easily identified and targeted by enemy artillery. The shelter that houses the computer has no armor so is vulnerable to any type of direct or indirect fire. Also, the computer has critical temperature restrictions and can lock up at temperatures as low as 75°. Although there is an air conditioner, if the AC power system is lost, it will not operate. The computer then overheats and lockup occurs. The computer is also susceptible to electromagnetic pulse (EMP).¹⁴

Another vulnerability of the fire support system is that the company FSO goes into combat with his supported armor or mechanized infantry unit riding in a Fire Support Team Vehicle (FISTV). While the company in their tanks or Infantry Fighting Vehicles (IFVs) have sufficient armor against indirect and small arms fire, the FISTV is a converted M113 armored personnel carrier that is more vulnerable and presents a distinctive target signature.¹⁵

A strength in the area of survivability is the redundancy of the system. If the TACFIRE battalion computer is put out of action, a battery using BCS can take over technical fire direction. Also, with the number of FSOs and observers, there should always be someone to request fire in every unit.

Mobility

There is adequate mobility in the fire support system. The

brigade and battalion FSOs have a M577 command post vehicle which becomes part of the maneuver unit's TOC. The FSO usually rides with the unit commander, which enhances coordination but can reduce the ability of the FSO to direct fires at the critical time. The company FSO has his FISTV which is not as mobile as the tank or IFV but can keep pace in most situations.¹⁶

Flexibility

Field artillery can range across the battlefield, change priorities rapidly, fire the most effective munitions when needed, and incorporate many systems to reinforce it. To provide this flexibility, the system must have experienced personnel. They must know when and how to use this flexibility to provide the greatest effects. The American system is lacking in this area. The reasons for this are inexperience at the fire support level and inability of the FSOs to control tactical fire direction.

The first position held by a new field artillery lieutenant is usually company fire support officer. A captain or senior lieutenant is normally placed in the battalion FSO position. Although a major is supposed to be the brigade FSO, the latter is usually a captain. Unlike most countries, the U.S. normally places its talent and experience with the guns rather than in the FSO positions where experienced judgment and maturity are especially needed. The rank structure authorized in the Table of Organization and Equipment (TOE) and normal unit assignment policies do not support these critical positions.¹⁷ Also, tactical fire direction is controlled by the FDO rather than the FSO who is with the maneuver commander. This practice reduces

flexibility by adding response time to changing situations and shifting priorities.

Conclusions

The current field artillery tactical data system, TACFIRE, emphasizes automated support for technical fire direction and provides limited support for command and control tasks. It is based on 1960s technology, has very limited survivability, requires centralized operations, and is too heavy for several divisions in the current force structure. TACFIRE's software is not modular and is therefore difficult and expensive to revise and maintain.¹⁰

The Fire Support Mission Area Analysis, done for the U.S. Army Field Artillery School, expresses the following deficiencies of the TACFIRE system:

- Inadequate automated support for fire support functions and fire support elements.
- Inadequate responsiveness and continuity of operations capability because of over-centralized processing.
- Size and power requirements hamper mobility and deployment.
- Unable to interface with other Army command and control systems, projected systems, or other fire support systems.
- Antiquated hardware and software cause difficulty in supporting and upgrading.
- Excessive initial and sustainment training requirements resulting in part from an inadequate man-machine interface.
- Does not do target value analysis effectively.
- Poor survivability because of excessive heat, noise, and electronic signature.

--Requires interruption of operations and time consuming manual tasks for fault isolation.¹⁹

The problems with the current American system are more than just the inadequacies of TACFIRE. The normal policy of placing the experienced officers near the guns rather than where they can control the fires is a major problem. The other significant fault is having the FDO control the tactical fire direction rather than someone near the maneuver commander who can make the judgment of what, where, when, and how missions should be fired. These two areas degrade the flexibility, responsiveness, and overall lethality of the system.

The U.S. system does have several good parts. It proliferates trained observers throughout the battlefield. Almost every maneuver unit down to platoon level has an observer. There are also Combat Observer Laser Teams (COLTs) and air observers throughout the battlefield. The variety of munitions allows the fire support personnel greater flexibility in their methods of supporting the maneuver commander. Finally, most of the observers have the means to stay as mobile as the units they support.

Soviet Fire Support System

Organization

The Soviet concept of the role of artillery is the opposite of the U.S. Unlike the U.S. precept that the purpose of fire is to support maneuver, the Soviets believe that the purpose of maneuver is to exploit the effects of fire.²⁰ The concept of "fire combat" is set forth as the main ingredient of the recipe for success for the attacker. Massed fires and extensive

artillery fire support are firmly entrenched in Soviet doctrine.²¹.

Soviet artillery is organized for combat into artillery groups. Groups may be formed at army, division, or regimental level for specific operations. An army commander may have at his disposal army level artillery and any front level artillery, such as an artillery division, allocated to his army, which he then either reallocates to divisions or forms into army artillery groups (AAGs). The AAG usually consists of long range field guns positioned 7-12 km. behind the Forward Edge of the Battle Area (FEBA) and normally assumes the primary counterbattery mission for the army.

A division executing a major army mission is allocated the most artillery from army level. The decision making process is then repeated by the division commander, resulting in the formation of a DAG and several regimental artillery groups. If necessary - because of span of control, number of battalions available, and assigned missions - the division may organize into more than one DAG. The DAG may vary in size from two to four battalions and is employed in general support of the division. The DAG assists the army and division with the counterbattery mission or, if capable, may perform this mission itself.

Regimental artillery groups are formed from organic and attached artillery and reinforcing nondivisional artillery battalions assigned to provide support to the first echelon maneuver regiments. RAGs are normally composed of two to four artillery battalions.

Artillery groups established for the defense are normally

maintained intact until the offense is resumed. Groups formed to support the offense are generally dissolved or reorganized when the supported maneuver units enter the exploitation phase of an operation.

At regiment and above, an artillery officer who plans and coordinates artillery fires serves on the staff of maneuver unit commanders. He is called the Chief of Artillery at regiment and the Commander of Rocket Troops and Artillery (CRTA) at division and above. At regiment and above, an artillery commander is also assigned to the maneuver unit and is directly responsible for the performance of the organic artillery unit. The artillery staff officer (CRTA) is responsible for controlling the artillery units organic or attached to his maneuver unit, although he does not command them. The CRTA also has the authority to inspect the artillery units in the division and to hold them accountable for their technical proficiency

Through his CRTA, the division commander may assign specific artillery units to provide support to designated maneuver units. In a fluid situation, such as in exploitation or pursuit, artillery support will be provided to lead maneuver units. The division commander retains the ability to form new groups as the situation may require.

An artillery battalion or battery assigned to a RAG could be directed to support a maneuver battalion during the course of an operation. The release from centralized control permits the artillery subunit to carry out missions in support of the specific maneuver battalion while remaining subordinate to the RAG. The commander of the attached artillery subunit acts as the

fire support coordinator to the maneuver battalion commander.²²

Tactical Fire Direction

Command and control of tactical fire direction for a battalion attached to a maneuver unit (direct support) is accomplished using a series of command observation posts (COPs). The main COP is used for controlling the fire and maneuver of the batteries within the battalion, conducting reconnaissance of the enemy, observing the terrain and actions of the maneuver units, and maintaining coordination with the maneuver commander. The battalion commander is located in the COP, generally positioned with the maneuver commander, along with his intelligence officer, scouts, and technical fire direction staff. Battery commanders occupy battery COPs co-located with the maneuver commander they are supporting.²³

In controlling fire, the artillery battalion commander must know the tactical situation, firing status of subordinate units, capabilities and location of his reconnaissance assets and means available of attacking the targets. Much of this is dictated to him by his higher commander or by the application of Soviet artillery norms. Currently, the only automated technical fire direction computer is located with the battalion chief of staff at the battalion fire control post. The battalion commander personally reconnoiters the enemy, performs adjustment on targets and observes the progress of combat and results of fire. He assigns fire missions to subordinate subunits and gives commands for requesting fire as well as transferring and ceasing fire. He monitors the execution of fire missions and reports to the senior commander or chief of staff the results and ammunition

expenditure. Also, he is ready to assume fire control of the artillery group in which his artillery battalion is included and prepared to take steps for immediate restoration of disrupted control.

Missions fired by the battalion are either preplanned or opportunity fire missions. Both are controlled by the battalion commander.

A preplanned fire mission is when the targets are reconnoitered, coordinates and size are determined, the mission is assigned to batteries, and target data is calculated and recorded by the gun commanders. The nature of the target and ammunition expenditure may be updated prior to execution of the preplanned fire mission.

An opportunity fire mission is when the targets are reconnoitered but the battalion is not assigned to engage them. Maneuver company commanders may request fire through their battalion commander who, if he approves it, passes it to the artillery battalion commander co-located with him.

By making a decision to execute an opportunity fire mission, the artillery battalion commander selects the most important targets for the success of combat mission. Proper choice of the target and determination of the moment for beginning its engagement are possible only through continuous observation of enemy and friendly actions. In his decision the artillery battalion commander determines the targets or target; the number of batteries or pieces to be used for firing on each target; type of fire; methods of engaging the targets; shell, fuze, charge and type trajectory; procedure for executing the fire missions;

method of determining fire for effect data; assets to be used for adjusting fire; shell expenditure; safety precautions for friendly troops; and signals for starting, transferring, and ceasing fire.²⁴

Characteristics of Fire Support

The Ability to Mass Fires

The Soviets have historically demonstrated an excellent ability to mass fires. During the Great Patriotic War, they did so by placing artillery weapons literally hub to hub across the front. Today mass is accomplished by organizing DAGs and RAGs for specific missions with detailed reconnaissance and fire planning under centralized control. This is especially important during a breakthrough operation where the Soviets will mass over 100 tubes per kilometer of front. The Soviets believe that 55-60 percent of all targets are destroyed by battalion fire, up to 25 percent are destroyed by the fire of an artillery group, and 15-20 percent are destroyed by batteries or separate pieces in direct fire.²⁵ The Soviet technical ability to achieve mass on a small single target is not as effective as that of the U.S. and British because of limited automated computer capability. There is only one computer per battalion. For this reason, batteries usually deploy in a line formation and the battalion's batteries are positioned 500-1000 meters from each other in a triangle formation.²⁶

Responsiveness

The Soviet system is very responsive to the needs of the maneuver for several reasons. First, the artillery battalion commander and the maneuver commander conduct a joint

reconnaissance of the objective. Targets, phase lines, and control measures are coordinated at the beginning of the planning sequence; therefore, the artillery commander understands exactly what he must accomplish. To the guidance given him and from his own view of the terrain and enemy, the commander applies Soviet artillery norms which dictate to him the amount, rate, and units of fire he must use to accomplish his mission. The end result is a very detailed fire plan that is a product of both commanders. If the artillery commander is not attached to a maneuver unit, this fire plan is directed to him by the CRTA.

During the execution of the plan, most missions are fired in time sequence that allows for a loss of communications with the firing elements or other types of interference. Since the artillery and maneuver commanders are co-located, any deviation from the plan, such as slowing the shift of fire to another phase line, can be accomplished easily. Detailed fire planning and a thorough understanding of what needs to be accomplished by both commanders, plus the co-locating of the two TOCs, provides responsiveness throughout the fire support system.²⁷

Survivability

The Soviet system has only adequate survivability. If the maneuver TOC is located and destroyed, the CDP is also damaged. If this happens, the centralized observation, computation, and control over the battalion disappears. This results in significant degradation of efficient fire support to the maneuver unit.

TOCs and CDPs are dug-in when ever possible and procedures are established to regain control of the unit if the CDP is

destroyed. The battery COP most distant from the battalion COP assumes control. But the person second in charge of the battalion, the chief of staff (positioned at the battalion fire control post), has to leave his location and find the maneuver unit chief of staff to establish another COP.

Although the system has established procedures to reconstitute the command and control element, destroying the COP would probably stop artillery support for quite some time. Also, with the COP and TOC being co-located close to the FLOT, they present a fairly easy target to identify by either direct observation or directional finding electronic warfare equipment.²⁸

Mobility

The COP normally deploys in a BRDM-2U, BTR-60, or the new ACRV-2 vehicle. Since the COP serves simultaneously as headquarters, forward observer, and fire direction center, it can be said that the Soviet system has excellent mobility. It usually has the same vehicle as the maneuver commander's TOC and can keep pace during tactical movement.²⁹

Soviet artillery has been going through a process over the last few years of conversion to self-propelled artillery. This greatly increases mobility as well as survivability because of the protection to personnel, ammunition, and communication equipment afforded by the self-propelled howitzers. The mobility also gives the artillery better speed to stay right behind moving tanks or IFVs that enable them to be used in their direct fire role.³⁰

Flexibility

The greatest failing in the Soviet system is flexibility. Emphasis on centralized control and the strict use of norms may cause the system to fail when it meets the unexpected. As already stated, loss of the CDP can be catastrophic. If a maneuver company commander runs into an unexpected situation, he must request fire support thru his battalion commander to the artillery battalion commander who determines how it will affect the rest of the fire plan of the battle. If the mission is to be fired, the artillery battalion commander transmits it to the chief of staff who computes the data and compares it with the data computed by the battalion commander and the batteries. Three or more checks are made on the technical data before the mission is fired. This entire process, if the mission is fired at all, takes several minutes, goes through many different channels, and is susceptible to electronic jamming. If the battalion supporting the unit is in support rather than attached, it belongs to a RAG or DAG so the mission has almost no chance of being fired. A lack of trained observers with the maneuver elements also degrades the system. Even battery commanders, who are also used as observers and fire planners, must go through the battalion commander for fire requests.

Conclusions

Overall, the Soviet system of command and control of tactical fire support is very good. Joint reconnaissance, fire planning, and co-locating the TDC and CDP provides for excellent coordination between the artillery battalion and the unit it supports. Having the senior artilleryman of the battalion, the

commander, doing the planning and present at the point of execution ensures an experienced decision at the most critical times. Task organizing massive amounts of artillery for critical missions allows for extensive support at the decisive point on the battlefield. Also, mobility is the same as that of the maneuver commander and adopting self-propelled howitzers increases speed, survivability, and flexibility.

But the system has two critical shortfalls. If the battalion commander is killed the system must react rapidly to make up for the loss. The overcentralization of the system gives an enormous amount of control to the battalion commander at the COP. It is the crucial link in the system and may be easily located on the battlefield. The second major drawback of the Soviet system is the lack of automation. So far, they only have a computer for technical fire direction. The inability to field an automated fire support system as part of an integrated army command and control network greatly degrades the potential of the large number of assets they possess.

British Fire Support System

Organization

The Royal Artillery's main strength is committed to the British Army of the Rhein where there are nine field battalions, one heavy battalion, and one Lance battalion. Stationed in Great Britain are four field battalions, one medium battalion, and six special units such as those that support the Marine Commandos and the airborne battalions. The Royal Artillery also controls anti-aircraft assets and some anti-tank missile units. The battalions are called regiments and are made up of varying

numbers of batteries such as 29 Commando Regiment which deployed to the Falklands with five firing batteries.³¹ Corps and divisions exist in the British Army as they do in others but the emphasis is at the regimental level. Division artillery is used to control fires for the division. It usually includes six close support batteries organized into two battalions; each battery consists of eight guns.³² The battery has been the basic unit of fire and is normally task organized with the maneuver regiment. There exists close personal and professional relationships among the forward observers, battery commanders and the personnel of the maneuver units as well as between the direct support artillery regimental commander and the supported brigade commander.³³

The close support artillery regiments are allocated in direct support of closely affiliated maneuver brigades. Batteries of those regiments are further assigned in direct support of an affiliated maneuver battalion. By using this method, fire support command and control is kept very decentralized.

Tactical Fire Direction

The British tactical fire direction system is built around the maxim taught to young gunners for generations; the weapon of the artillery is the shell - not the gun. It is the projectile with its explosive charge that counts, not the equipment of delivery, which is only a means to an end.³⁴ The British also believe that the first priority must always be to close support of the maneuver arms.³⁵

Adherence to these principles has created a very different

fire support command and control structure from that of the U.S. Army. The principle at all levels from corps to company is that the supported commander should deal with a single artillery commander as his advisor, not a junior liaison officer. Therefore, like the Soviets, the commander is his own fire support officer.

The commander of the direct support battalion establishes his TOC as part of the supported brigade main TOC. His TOC (along with the air force, air defense, and army aviation elements) becomes the Fire Support Coordination Center (FSCC) and functions closely with the brigade operations and intelligence staffs as well as with the supporting engineer staff.

The commander normally travels with the brigade commander. This ensures concurrent development of the tactical and fire support plans and the timely coordination of effort throughout the subordinate units. The commander is in constant contact with his unit and DIVARTY. The commander's TOC oversees the implementation of the artillery orders and the fire support plans. His operations and intelligence officers are also located in his TOC. He coordinates the deployment of all indirect fire resources deployed in the supported brigade's area of responsibility on behalf of the DIVARTY commander.

Technical fire control for the direct support battalion is controlled by the Regimental Command Post Officer (RCPO), a captain, located in the gun area. The firing battery also has a captain called the Battery Captain to run the position. Their job is to execute the fire orders sent to them by the commander. The 2IC (executive officer), a major, functions from the

battalion gun area. He assigns gun positions, coordinates survey, resupply, replenishment, and unit administration and is prepared to move forward to relieve the commander as required.

The battery commander, a major, functions in a similar manner as his battalion commander. In addition to providing advice, fire support coordination, and supervision of the FSCC in the maneuver battalion TOC, the battery commander has several other responsibilities. He directs the fire, artillery and other, under his control and deploys the Forward Observation Officers (FOOs) and other observation resources as allotted to meet the requirements of the artillery observation plan provided by the artillery battalion commander. He directs, or gives direction to, his observers for target engagement and, if required, engages targets himself. He coordinates the deployment of air defense, target acquisition and higher artillery resources deployed in the battalion area of responsibility and sub-allocates ammunition and fire units to his FOOs. Because he is the battery commander, he plans and orders the movement of his battery as well as any other artillery placed under his command.

The FOO is a captain. FOO parties are allocated normally one per maneuver company and consist of the captain, an NCO and four drivers or radio operators. The FOO is the fire support adviser at the company level and initiates/coordinates fire support requirements for the unit. He is either with the commander or in the best position to observe the targets. He arranges for continuous observation of his zone and employs his assistant and the attached mortar fire controller. The FOO is directly involved with the planning sequence of his supported

unit commander which allows him to anticipate and meet his commander's needs. The FOO can also request and direct close air support through artillery channels.

FOOs are authorized to order fire from their own battery, although fire missions are controlled by the battery commander who filters and re-directs calls for fire as necessary. The FOO may be authorized by the artillery battalion commander to fire part or all of the battalion and, as authorized by the DIVARTY commander, all or part of the DIVARTY. These calls for fire are treated as orders to the guns so allocated and may be sent straight to the controlling headquarters of the firing element.³⁶

Currently, the British system is undergoing two significant changes. First, from lessons learned during the Falklands campaign, the battalion is starting to become the unit of fire rather than the battery.³⁷ Although several thousand rounds were fired on Argentine positions, post campaign interrogation of the enemy indicated that close support fire caused very little damage. Success was achieved, however, when firing on command and control or logistics nodes. There is a need to concentrate the fire of a number of batteries onto a target rapidly if decisive results are to be achieved. It was deduced that with the current limited resources of the British artillery and the relative inadequacy of the destructive capability of the high explosive round, the needed response is the ability to switch massed fires from target to target rapidly.³⁸

Another major change is the adoption of the Battlefield Artillery Target Engagement System (BATES). This computerized

fire control system will replace several technical fire control systems and will integrate with the Wavell automated command and control system which is being fielded throughout the British Army.³⁷ BATES consists of automatic data processing equipment and programs to enable artillery commanders to make the most effective use of their resources. BATES will also do technical computations, resource management, and ammunition management via digital communications. It will recommend to the commander an engagement option as the best solution for the defeat of a particular target. Fire missions received will be placed in order according to the commanders priorities. When a target is selected for engagement by the commander, BATES recommends a fire order based upon a knowledge of weapon availability, range, effectiveness, ammunition availability and any constraints. Once approved by the commander, the fire order is passed digitally to the firing units, battery commanders, and observers; thus BATES will give the British a much improved means to mass fires rapidly and accurately. The focal point of the system will be the artillery battalion commander who will usually mass his batteries rather than have each of them fire separately at their own designated target.⁴⁰ This will have an impact on the close relationships between batteries and their supported units. No longer will the battery commander be able to guarantee artillery fire for his supported battalion.

Characteristics of Fire Support

The Ability to Mass Fires

Although the ability to mass has been present for many years, it was a very time consuming process and not often used

because it upset the direct support relationship of the close support battery and cluttered fire nets such that FOOs trying to fire other missions could not communicate with a fire unit.⁴¹ BATES gives the fire support system excellent ability to mass all battalions within range of the target. Because it is linked to the army system, it will have the latest intelligence information which will identify lucrative targets and specify the best time to engage them to get the best results. BATES makes it possible to use the limited British artillery assets to their fullest potential.

Responsiveness

The British system is very responsive as long as the support required comes from a single battery. The FOO calls straight to his designated battery. If additional support is required, and depending on the tactical mission assigned to each battery, the FOO calls to battalion FDC. Coordination between battalions is slow if additional battalions are needed to engage a target. Also, if the artillery FOO wants to fire his battery plus the unit mortars, a separate mortar fire controller is used to fire the mortars. BATES will significantly increase the responsiveness of the system as a single FOO will have the ability to call and control all indirect fires, including mortars, in his area. Also, digital communications decrease transmission time greatly as compared to voice communications.⁴²

Survivability

The fire support system is very survivable. This is a result in a large part of redundancy. There are several FOOs with the units who as captains, could easily assume the duties of

their battery commander if he is lost. The same can be said at regimental level where there are at least four majors who could take over for the commander. BATES also enhances system survivability by using digital communications, redundancy of nodes, and interoperability with the Wavell system. The British are looking into the feasibility of a product improvement package for its artillery pieces similar to the U.S. HIF, which does away with battery positions and spreads the guns over several kilometers.⁴³

Mobility

The British artillery fire support personnel have the same mobility as their maneuver commander. They usually co-locate in or near the maneuver TOC for better coordination and the BATES system is small and light enough to fit in a small TOC vehicle.

Flexibility

Experience in the fire support system ensures excellent flexibility. By having captains as FOOs and majors as battery commanders acting as their own fire support officers, unforeseen problems are more easily handled. The performance of the British artillery in the Falklands campaign testifies to this. It validates the principle that the round is the weapon not the gun. The experienced personnel have the ability better to support the maneuver commander's plan and aid him in ways that inexperienced observers and FSOs cannot. The battery commander is responsible for the integration of all weapons of the maneuver team into the overall plan. He has detailed knowledge of all direct and indirect systems and can place them to do the most good. He is the person who takes command of the maneuver unit if something

happens to the commander as the one most familiar with the situation and weapons systems available.⁴⁴

Conclusions

The British have very limited resources. They believe that the best way to use them is by placing the artillery commanders with the maneuver units to control the assets close to the point of impact instead of at the gun line. This process has been successful for them as long as they fired a dedicated close support battery for each maneuver battalion and did not want to coordinate fires with the mortars. BATES is a major step in easing these problems as it will increase the ability to mass accurate responsive fires on critical targets.

The strength of the British system is their philosophy of the round being the weapon instead of the gun. Senior fire support commanders run the system, not less experienced liaison officers. This ensures excellent coordination between fire and maneuver. It provides them exceptional ability to make changes when necessary and gives flexibility to respond to an unpredictable battlefield.

Advanced Field Artillery Tactical Data System (AFATDS)

Organization

The fielding of AFATDS will not cause a major organizational change in the American field artillery, although it is anticipated that it will reduce personnel requirements as well as the number of military occupational specialties. Artillery TOCs will become smaller as functional areas are realigned with the fire support elements of the maneuver TOC.⁴⁵

Tactical Fire Support System

Because of the inherent weaknesses of the original TACFIRE system and the problems demonstrated at the NTC, the U.S. field artillery has a requirement for a better automated command and control system to carry out its fire support coordination responsibilities effectively through 1990-2010.⁴⁶ TACFIRE emphasizes automated support for technical field artillery operations and provides limited support for tactical fire direction. But it is more than TACFIRE that the Field Artillery School decided to change with the adoption of AFATDS; they also adopted a new command and control philosophy.

AFATDS is first and foremost a fire support command and control system that performs target generation and processing for all fire units in a force. The basic unit is the Fire Support Terminal (FST). This is a stand alone computer no larger than a briefcase; however, it can also be used as a node in a distributed computer network.⁴⁷

In addition to the new computer network, the major change to the fire support system is that with the new equipment comes the ability to move the control of tactical fire direction from the artillery fire direction officer (FDO) to the Fire Support Officer (FSO) located with the maneuver commander. Priorities for the use of the indirect fire assets will be made by the maneuver commander and input into the computer by the FSO. This makes the system much more responsive to the changing battlefield and the desires of the maneuver commander. The field artillery battalion commander will have the largest part of his Tactical Operations Center (TOC) co-located at the maneuver TOC. AFATDS

will enable the commander and the FSO to see and evaluate the situation in order to influence the action in a more timely manner. AFATDS will support the maneuver and artillery commanders in exercising command and control by providing instant access to battlefield geometry and graphic displays of the tactical and logistic situation. AFATDS, in comparison to TACFIRE, will implement more detailed and sophisticated commander's guidance in the automation of operational planning, movement control, targeting, target value analysis, and execution. 40

Characteristics of Fire Support

Mass

AFATDS will be the single system for all fire support command and control. It emphasizes integration of all fire support assets into the battle plan at the FSE. AFATDS is compatible with allied fire support and field artillery systems using agreed upon international standards. It will interoperate with the Marine Integrated Fire and Air Support System (MIFASS); however, there are currently no Air Force or Navy data systems for which an interface requirement has been identified. Interoperability with these services will be effected through co-location with Army liaison fire support personnel at all maneuver TOCs and by use of Army personnel located with the other service headquarters. AFATDS will be capable of processing and passing pre-planned and immediate air requests. AFATDS will also be capable of using Joint Interoperability of Tactical Command and Control Systems (JINTACCS) message formats. The interoperability function of AFATDS allows the FSO better

efficiency in the application of fire support means in his area to attack targets. He will be able to mass more assets, more rapidly, using a single control system.¶

Responsiveness

In addition to the rapid transmission of information, AFATDS has the capability to prioritize critical message traffic and processing functions thereby ensuring responsive information exchange and mission accomplishment. It will do many functions automatically that will save time and ensure accuracy. An example of this capability is in fire support planning. Upon receipt of maneuver courses of action, including the FSO's guidance associated with an operational plan, AFATDS analyzes each course of action, rank orders them according to their supportability by fires, and prepares a report of the results for the maneuver commander. After the commander selects his course of action, AFATDS produces and disseminates the commander's guidance parameters associated with the OPLAN, the fire support plan, and the annex to the OPLAN. This capability ensures that the maneuver commander understands exactly what indirect fire assets he has in support and reduces planning time significantly.¶

Survivability

Survivability is a major problem of all computers used today. They produce a significant electronic signature, have low tolerance of extreme temperatures, and require significant maintenance. AFATDS has several built-in survivability factors. A key element is the concept of distributing processors associated with individual functions to various locations giving

each subsystem a single self-contained device of common design with sufficient processing capability to accomplish required functions. This ensures that the loss of a single processor will not result in system failure. Unlike TACFIRE, AFATDS will operate at temperatures from 0°F to +122°F and withstand humidity of 95%.²¹ Not only will AFATDS be able to withstand contamination by chemical and biological agents, it will be fully functional after decontamination. It will also survive without permanent damage or major performance degradation after exposure to nuclear radiation (gamma and neutron). Common hardware for all Army computer and communications will also aid survivability. As a passive control system, AFATDS is not likely to be discretely targeted by conventional electronic warfare systems because the electronic signature will not be distinctive to the system.²² Overall, the AFATDS will be far more survivable than the present TACFIRE system.

Mobility

The AFATDS hardware will be as small and lightweight as possible. Dimensions and weight will facilitate configuration with other fire support equipment in any vehicle of the Army standard family of vehicles. Vehicular mounted hardware will be capable of operation while on the move at speeds commensurate with other vehicles in the formation. The Forward Entry Device (FED) will replace the current Digital Message Device (DMD) for foot-mobile observers. The FED, together with sufficient batteries for 72 hours of surge operation, will weigh no more than eight pounds. Field artillery commanders, FSOs, operations officers, and many other command and control personnel will be

equipped with the FST to operate when they are separated from their command posts. This terminal will allow them to monitor the situation, give guidance, and issue orders.⁵³

Flexibility

AFATDS promotes flexibility by using common hardware, modular software, and distributed data bases. Common hardware permits relocation of terminals from less critical to more critical facilities, or allows functions to be shifted between terminals located in the same facility. Software will be modular in design for interchangeability and easy modification. The system is designed so that changing technology, doctrine, tactics, weapons capabilities, and procedures can be accommodated. Software is written in Ada, the standard Department of Defense language, allowing inter-service compatibility. It will also interoperate with the control systems of the other four functional areas of the Army Command and Control (ACCS). The primary AFATDS interface points will be at the FSEs located with the maneuver operations centers. The interface will use established ACCS message formats and protocols.⁵⁴

Conclusions

AFATDS will be employed in support of the tactical fire direction functional area. During the first few years of AFATDS, BCS will control technical fire direction. When the system is completely fielded, it will add the technical computation of firing data to its list of capabilities but its main function will remain as the coordination and control element for fire support.⁵⁵

The computer system will be used by all cannon, rocket, and missile units in the active and reserve forces. It will be used at Fire Support Elements (FSE) located with maneuver battalions, brigades, divisions, and corps as well as at field artillery command posts from the field artillery firing unit to Echelons Above Corps (EAC).²⁶

It will provide an extensive information system which will take full advantage of combat net radio, data distribution, and area communications media to support the decision making process. In all areas, AFATDS is proposed to be significantly better than the present TACFIRE system.

Conclusion

The purpose of this paper was to determine the most appropriate fire support system for the U.S. Army. From the study of the present TACFIRE system, the Soviet and British systems, and the future AFATDS, three major conclusions are drawn. If these conclusions are incorporated into the fire support command and control structure, it will significantly enhance the system and provide better support to the maneuver arms.

1. Future planned automation will greatly enhance the capabilities of fire support assets.

This study shows that technology is, and will be, the major influence on future command and control systems. The advances made by the new American and British systems put them far ahead of other fire support systems because of their increased capabilities, survivability, and flexibility. The silicon chip is changing the way armies fight. As firepower becomes more

deadly and expensive, it is clear that indirect fire support cannot be controlled merely by firing tables, range charts, and time consuming manual fire planning. The mechanization of forces, enhancing their agility, has made the time window in which to engage each threat on the modern battlefield very narrow. Control techniques have to be more flexible, providing more rapid response. It is this increased efficiency that the latest and future fire control systems must provide. Microprocessors ensure that these present and future needs are met.

Computerized fire support systems are being integrated into overall army command and control systems. These systems seek to reduce the elements of chance and friction on the battlefield by feeding certainty into the commander's decision cycle and allowing the computer to make recommendations from the commanders guidance. Missions are assigned on a more logical basis and expended ammunition has a higher probability of effectiveness. The computer allows for more efficient control of many fire support assets during the battle.

All fire support systems analyzed here are increasing reliance on computers to control their assets. While the Soviets are using their first generation computer at battalion level, the U.S. is about to field a third generation computer that will be linked with the overall army command and control network.

Automation has greatly altered techniques for control of fire support. But while computers increase efficiency in the fire support command and control system, the man-machine interface ultimately determines its effectiveness.

2. The fire support system is improved if the fire support officer controls fires instead of the fire direction officer.

Each organization studied employs fire support personnel in different ways. The current U.S. TACFIRE system places the experienced personnel with the guns. The final decision of what, where, and how to fire a mission is made by the battalion FDO in the computer shelter located at the artillery battalion TOC. The Soviets place almost the total control of fires with the artillery commander. Much of his firing is controlled by the fire support plan that he prepares in concert with his supported commander after a joint reconnaissance or by the CRTA if his unit is part of a RAG or DAG. While executing the plan, if any changes are necessary, he takes control, observes and adjusts the fire, computes data, and moves his units. The British place their most experienced personnel with the maneuver unit. Like the Soviets, this is where the fire support system is controlled. Their system is not as centralized as the Soviets and provides more flexibility and redundancy. The AFATDS will be a significant change to the U.S. system. Control of all fires will be accomplished by the FSO instead of the FDO. This will increase the speed, reliability, and flexibility of the system. The FSO, located with the maneuver commander, can easily change the fire support priorities to fit the dynamic battlefield and the commanders changing plan.

3. There needs to be a philosophical change within the U.S. fire support community.

Though AFATDS makes a great step to increase the capabilities in the fire support system, a fundamental change

needs to take place to make the system even better. The U.S. must alter its philosophy of placing its experienced personnel with the guns to adopting the British and Soviet practice of placing experience forward with the maneuver commanders. Although AFATDS does move a critical part of the decision making process to the FSO, the many judgments that need to be made at the lower maneuver level are still made by lieutenants. The British have captains and majors making these critical decisions while the Soviets use battery and battalion commanders. Reports from NTC and other sources show that more experience is needed in the fire support area.⁸⁷ LTG J. Lawton Collins once said about his use of observers during World War II, "When it came to fighting we put the best artillerymen up as the forward observers. Battery commanders. People really expert in their job. Not some poor second lieutenant wetting his feet for the first time."⁸⁸ Although personnel restrictions prohibit the U.S. Army from increasing the rank structure of the company FSO, there are ways to field more experienced observers. Lieutenants should not be assigned as a company FSO until they have had battery experience, preferably as a fire direction officer. Also, FSO positions should be filled within battalions before any other jobs except commanders and the battalion executive officer.

Future wars, technological changes, and force design greatly increase the strain on the ability of the field artillery to control indirect fires. AFATDS plus the changes mentioned can greatly increase the effectiveness of the U.S. fire support system and guarantees that the maneuver arms is always supported with timely, accurate, lethal and coordinated fires.

END NOTES

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² FM 100-5 Operations (Ft. Monroe: TRADOC, 1986), pp. 2-5.

³ "Organizational and Operational Plan (O&O Plan) for The Advanced Field Artillery Tactical Data System" Revised draft report, (Ft. Sill: USAFAS, 23 June 1986), p. 3-4.

⁴ FM 6-20-2J Division Artillery, Field Artillery Brigade, and Corps Artillery Headquarters (Ft. Monroe: TRADOC, 1985), pp. 1-1 - 1-2.

⁵ FM 6-20-2J, p. 2-1.

⁶ TC 6-1 TACFIRE (Ft. Sill: USAFAS, 1977), pp. 2-5.

⁷ FM 6-40 Field Artillery Cannon Gunnery (Ft. Monroe: TRADOC, 1984), p. 1-4.

⁸ Most infantry FISTs have ten members. Two man observer teams are attached to platoons to control company and battalion mortars. Armor FIST have only four members and no platoon observer teams. Combat Observation Lasing Teams (COLTs) of two soldiers may also be attached to a FIST to control Copperhead fires or to add more depth to the team. COLTs are controlled by the FSO. FM 6-20, pp. 2-2 - 2-9.

⁹ FM 6-1 Field Artillery Fire Direction System TACFIRE Operations (Ft. Monroe: TRADOC, 1984), p. 7-8.

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¹¹ FM 6-1, p. 6-11.

¹² William S. Fier, "Field Artillery Focused Rotation, NTC 86-5," Report, (Ft. Sill: USAFAS, 28 Feb. 1986), p. 6.

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¹⁷ Crossley.

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¹⁹ O&O Plan, pp. 2-3.

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²² William F. Baxter, Soviet Airland Battle Tactics, (Novato: Presidio Press, 1986), pp. 183-185.

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²⁴ Foreign Broadcast Information Service (FBIS), "The Artillery Battalion In Combat," USSR Report, 1 May 1985, p. 45.

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²⁶ Baxter, pp. 188-189.

²⁷ FBIS, pp. 31, 32, 34.

²⁸ FBIS, p. 26.

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⁵² ROC Plan, p. 8.

- 83 O&O Plan, P. 11.
- 84 ROC Plan, p. 5.
- 85 ROC Plan, p. 28.
- 86 O&O Plan, pp. 21-23.
- 87 Although this problem can be found in most NTC after action reports, the Crossley letter expresses it best.
- 88 "Conversations With General J. Lawton Collins," Report, (Ft. Leavenworth: Combat Studies Institute, 17 May 1983), p. 8.

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